Studies on Irradiation of Agar–Agar in the Solid State: On the Changes of Water Holding Capacity of Agar–Agar Hydrogel Produced by Irradiation

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Synopsis

Solid agar–agar was irradiated with ^{60}Co gamma-rays, and effects of radiation on the water-holding capacity of agar–agar molecules were studied by measuring the water content of the agar–agar hydrogel. The effects of postirradiation were also studied. Empirical equations of changes of water holding capacity were obtained.

INTRODUCTION

It is well known that many molecules are rendered less stable when they are irradiated,[1-4] and also that some polysaccharides, such as agar–agar and carrageenans, form a hydrogel.[5-10] However, the interrelationship between water and polysaccharide in a gel is not clear. The effects of radiation on agar–agar are also of interest to those who study the effects of radiation on organisms grown in this biomaterial. It was, therefore, considered desirable to study the effects of radiation on the water holding capacity of the agar–agar molecule.

Changes in the water-holding capacity were elucidated conveniently by measuring the water content of the agar–agar hydrogel as functions of radiation dose and elapsed time after irradiation.

EXPERIMENTAL

Agar–agar used in this work was a commercial material produced by the Junsei Chemical Co., Ltd.

The solid agar–agar was irradiated with ^{60}Co gamma-rays in air at room temperature at a dose rate of 1.3×10^5 rad/h. After irradiation the agar–agar was dissolved with distilled water in the concentration of 2% at about 100°C, and molded at room temperature for 24 h. Then the water content was measured using an infrared-ray water meter. The results obtained were expressed in terms of relative release time of water, W/W_0, where W and W_0 are 50% water release times (min) of the irradiated and nonirradiated agar–agar hydrogels, respectively.

RESULTS AND DISCUSSION

The changes of W/W_0 value of the agar–agar hydrogen at various radiation doses were studied with 2% agar–agar hydrogel. The experimental results

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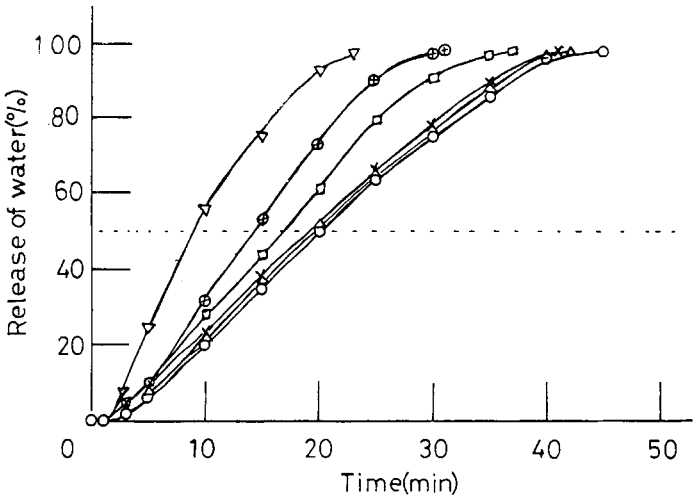

Fig. 1. Release of water (%) vs. release time for various radiation doses (rad): (○) 0; (△) 10^4; (×) 10^5; (□) 10^6; (⊕) 3×10^6; (▽) 10^7. Conditions: 2% agar–agar hydrogel.

are shown in Figures 1 and 2. Figure 1 shows the relationships between release of water (%) and water release time at various radiation doses. Figure 2 shows the relationship between W/W_0 value and radiation dose. The W/W_0 value of the irradiated agar–agar was found to follow the following equation:

$$W/W_0 = \exp(-kr)$$

where r is the absorbed dose (rad) and k is 0.85×10^{-7}.

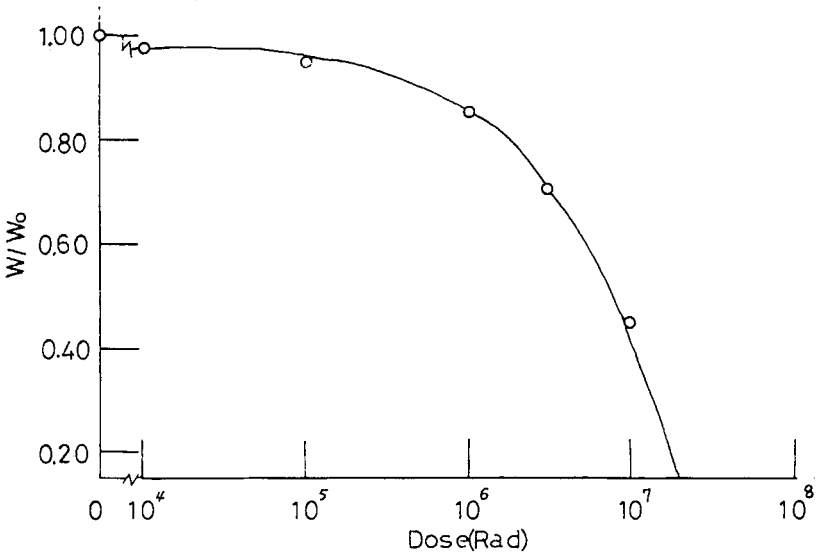

Fig. 2. Relative release time of water (W/W_0) vs. radiation dose. Conditions: 2% agar–agar hydrogel.

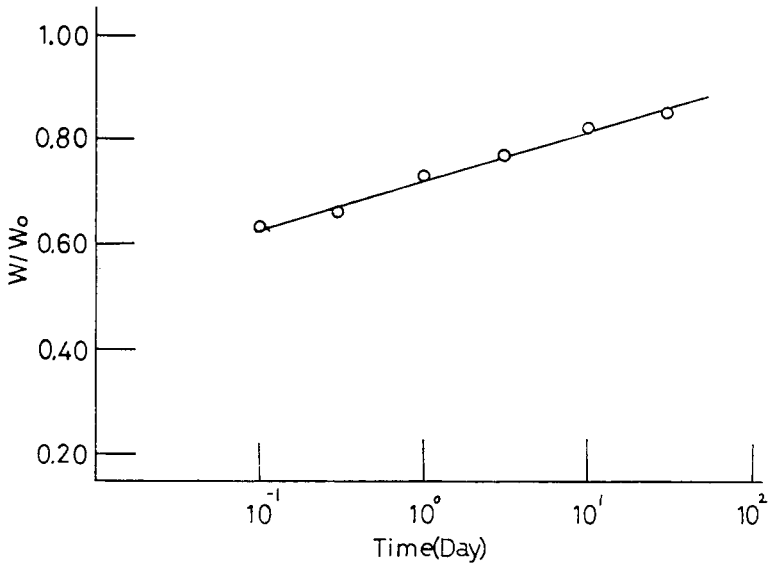

Fig. 3. Relative release time of water (W/W_0) vs. time after irradiation. Conditions: 2% agar–agar hydrogel and 2×10^6 rad.

Since 3-dimensional networks in the case of the agar–agar hydrogel must be entrapped in considerable amounts of water and formed by crosslinks between polysaccharide chains, the W/W_0 value is related to the water holding capacity of the agar–agar molecule. When the concentration of the agar–agar is constant, an increase of the absorbed dose may be concerned to a decrease of the water-holding capacity due to destruction of the agar–agar molecule caused by gamma irradiation. Therefore, the response of the water holding capacity of the agar–agar molecule to the radiation dose can be determined by measuring the water content. In the system, the crosslinking loci of the agar–agar molecule seem to be broken by ionizing radiation, the formation of the crosslinks is depressed, and, as a result, the W/W_0 is decreased.

The changes of W/W_0 value of the agar–agar hydrogel at different times after gamma-irradiation (2×10^6 rad) were studied with 2% agar–agar hydrogel. The results obtained are shown in Figure 3. It can be seen that the W/W_0 value of the irradiated agar–agar follows the following equation:

$$W/W_0 = a + b \log t$$

where t is the elapsed time (day) after irradiation and a and b are 0.72 and 0.95×10^{-1}, respectively.

From the above equation, it is found that, at a constant concentration of agar–agar and a constant radiation dose, the increase of the W/W_0 value by recovery of the water-holding capacity of the irradiated agar–agar molecule depends on the elapsed time after irradiation. Thus, the response of the water-holding capacity of the irradiated agar–agar molecule to the time after irradiation can be determined by measuring the water content. Recovery occurs in the broken crosslinking loci of irradiated agar–agar molecule, the crosslinks are restored, and, as a result, the W/W_0 value is recovered until a certain value ($W/W_0 < 1$).

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